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Health and Environmental Effects
Profile for Bromoethene (Vinyl Bromide)

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HEALTH AND ENVIRONMENTAL EFFECTS PROFILE
FOR BROMOETHENE (VINYL BROMIDE)

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PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEP's are intended to support listings of hazardous constituents of a wide range of waste streams under Section 300i of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEP's will become part of the EPA RCRA docket.

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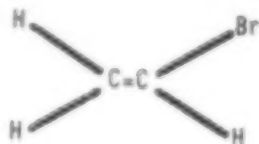
LIST OF ABBREVIATIONS

DNA	Deoxyribonucleic acid
LD ₅₀	Dose lethal to 50% of recipients
ppm	Parts per million
RBC	Red blood cell
RNA	Ribonucleic acid
STEL	Short-term exposure limit
TLV	Threshold limit value
TWA	Time-weighted average

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

The name commonly used for bromoethene is vinyl bromide; it is also known as bromoethylene (IARC, 1979). The structure, molecular formula and molecular weight of this compound are as follows:



Molecular formula: C_2H_3Br

Molecular weight: 106.9

The Chemical Abstract Service (CAS) registration number for vinyl bromide is 590-60-2.

1.2. PHYSICAL AND CHEMICAL PROPERTIES

Vinyl bromide is a colorless gas at ambient temperature and pressure (Larsen, 1980). It has the following physical properties:

Melting point: $-137.8^{\circ}C$ (Stenger, 1978)

Boiling point: $15.8^{\circ}C$ (Stenger, 1978)

Density at $20^{\circ}C$: 1.5152 g/cm^3 (Stenger, 1978)

Vapor pressure at $20^{\circ}C$: 1033 mm Hg (Torkelson and Rowe, 1981)

Solubility in water: No data available. The solubility of this compound in water can be speculated to be less than that of vinyl chloride. The water solubility of vinyl chloride has been reported as 1.1 mg/l at $25^{\circ}C$ (Verschuere, 1977) and also as 60 and 2700 mg/l at 20 and $25^{\circ}C$, respectively (Dilling, 1977).

Conversion factor: 1 ppm in air = 4.4 mg/m^3 at $25^{\circ}C$ and 1 atmosphere pressure

1.3. PRODUCTION DATA

Vinyl bromide is produced by only one manufacturer in the U.S. An undisclosed amount of this compound is produced by Ethyl Corp., Magnolia, AR (SRI, 1982; USITC, 1982) by the reaction of potassium hydroxide on ethylene dibromide (Oser, 1980).

1.4. USE

Vinyl bromide is used primarily as a flame retardant in the manufacture of modacrylic fibers. Its copolymer with vinyl chloride is also used for preparing films, for laminating fibers and as rubber substitutes (Larsen, 1980).

2. ENVIRONMENTAL FATE AND TRANSPORT

The fate and transport of vinyl bromide in the environment are not known with certainty because of the lack of investigative work in this field. Due to its high vapor pressure (1033 mm Hg at 20°C), vinyl bromide introduced into aquatic systems will most probably be transferred quickly to the atmosphere through volatilization. Based on the experimental evaporation half-life of <0.5-5.0 hours for vinyl chloride under stirring or quiescent conditions (Callahan et al., 1979), the evaporative half-life of vinyl bromide can be speculated to be a few hours.

Based on the expected similarity of this compound with vinyl chloride, vinyl bromide is not likely to undergo significant oxidation, hydrolysis and biodegradation in the aquatic environment (Callahan et al., 1979). Despite the expected slight bathochromic shift (shift to longer wavelength) due to the bromine atom (Calvert and Pitts, 1966), vinyl bromide, like vinyl chloride, may not undergo significant photochemical reaction in aquatic media (Callahan et al., 1979). Also, drawing on the similarity of vinyl bromide with vinyl chloride, neither sorption nor bioconcentration appears to be an important transport process.

Like vinyl chloride, vinyl bromide may not undergo significant direct photochemical reaction in the atmosphere (Callahan et al., 1979), but it can react with both $O(^1P)$ atoms and $OH\cdot$ radicals in the atmosphere.

The rate constants for the reaction of $O(^1P)$ atoms with vinyl bromide have been determined to be 6.5×10^{-12} cm³ molecule⁻¹ sec⁻¹ and 5.65×10^{-12} cm³ molecule⁻¹ sec⁻¹ at 27 and 25°C, respectively (Atkinson and Pitts, 1977; Slagle et al., 1974). Other authors have determined similar rate constant values for this reaction (Atkinson and Pitts, 1977).

At an atmospheric $O(^3P)$ atom concentration of 2.5×10^4 molecule cm^{-3} , the half-life of vinyl bromide for $O(^3P)$ atom reaction is ~500 days (Graedel, 1978). Therefore, this reaction may not contribute significantly in determining the fate of vinyl bromide in the atmosphere. The rate constant for vinyl bromide reaction with $OH\cdot$ radical has been determined to be 6.81×10^{-12} cm^3 molecule $^{-1}$ sec $^{-1}$ (at 25°C) (Perry et al., 1977). At an atmospheric $OH\cdot$ radical concentration of 4.1×10^5 molecules cm^{-3} , the half-life of vinyl bromide can be calculated to be ~3 days (Graedel, 1978). Considering the reaction of radicals as the most important fate-determining process for atmospheric vinyl bromide, it can be assumed that this compound of low solubility and high vapor pressure will participate at least in short-range aerial transport processes.

The fate and transport of vinyl bromide in soil can only be speculated upon since no comprehensive experimental study has been made. Considering the high vapor pressure and the expected low sorption coefficient in soils based on similarity to vinyl chloride (Callahan et al., 1979), this compound is expected to be transferred quickly to the atmosphere through volatilization. The biotransformation possibility of vinyl bromide in soils cannot be predicted unless evidence of such biotransformation is available. Although leaching of vinyl bromide from soil to groundwater may occur in certain instances, the probability of leaching is expected to be very small. This speculation is based on the fact that vinyl chloride was detected in <1% of the groundwater samples monitored throughout New Jersey (Page, 1981).

3. EXPOSURE

No quantitative monitoring data for this compound in any ambient environmental media could be found. DeCarlo (1979) identified the presence of vinyl bromide in the air near a manufacturing site in Magnolia, AR. Oser (1980) reported the presence of vinyl bromide under occupational conditions inside a manufacturing plant in Magnolia, AR. The following levels of vinyl bromide were monitored at the breathing zones of different job locations: plant operator, 0.1-0.4 ppm; laboratory technician, 0.3-0.5 ppm; and loading crewman, 1.2-6.3 ppm.

4. PHARMACOKINETICS

4.1. ABSORPTION

The inhalation kinetics of vinyl bromide have been studied extensively in Wistar (Filser and Bolt, 1979) and F344 (Andersen et al., 1980) rats. Filser and Bolt (1979) developed a closed vapor exposure system to study the gas uptake of experimental animals. Three male rats were placed in the 10.3 l chamber, which contained ~300 ppm vinyl bromide vapor. The decline in vinyl bromide concentration was monitored at various intervals for up to 10 hours. A rapid decline in vapor concentration was observed during the first half hour of exposure. This was attributed to the equilibration of vapor between the rats and the exposure system. A second phase of concentration reduction occurred up to the sixth hour of exposure, and was observed to follow zero-order kinetics. The concentration of vinyl bromide at the sixth hour of exposure was ~55 ppm. A third phase of concentration reduction occurred from the sixth hour onward, and was observed to follow first-order kinetics. The elimination of vinyl bromide in the chamber was reported to be a saturable, dose dependent process, with saturation occurring at exposure levels in excess of 55 ppm.

Andersen et al. (1980) also used a closed recirculating exposure system to determine kinetic constants for the uptake of vinyl bromide in three male F344 rats. Vinyl bromide was observed to adhere to saturable uptake kinetics. The maximum rate of gas uptake (V_{max}) in this (31 l) chamber was obtained from the best fit in an Eadie-Hafstee plot and was equivalent to 2.1 mg/kg/hour. A concentration of 18.4 ppm was observed for K_m , the concentration at which uptake is one-half V_{max} .

4.2. DISTRIBUTION

A four-compartment pharmacokinetic model was postulated by Andersen et al. (1980) to describe the gas uptake data observed in rats in their closed exposure system. The rate limiting steps at low concentrations appeared to be during respiration and hepatic perfusion (compartment 1), while at high concentrations, the rate limiting step was in the capacity of the liver to metabolize vinyl bromide (compartment 4).

The first compartment, the gas phase, was shown to equilibrate quickly with the blood and richly perfused tissues (compartment 2). Poorly perfused tissues (compartment 3) do not equilibrate as quickly, and accumulate vinyl bromide. The fourth compartment comprises metabolite production and elimination.

4.3. METABOLISM

Barbin et al. (1975) reported that liver microsomal systems can activate vinyl bromide to reactive electrophiles. Vinyl bromide vapors were passed through a mouse liver microsome suspension, and 2-bromoacetaldehyde, a volatile alkylating agent, was formed. Bartsch et al. (1979) reported evidence of 2-bromoethylene oxide formation upon incubation of mouse liver microsomes in the presence of vinyl bromide, oxygen and NADPH. Production of alkylating metabolites from vinyl bromide by microsomal activation has been reported by other investigators, including Bolt et al. (1981, 1982), Ottenwalder and Bolt (1979, 1980), Guengerich (1981) and Guengerich et al. (1981). These investigators postulate that vinyl bromide is metabolized to the epoxide, 2-bromoethylene oxide, followed by rearrangement to 2-bromoacetaldehyde.

Guengerich (1981) and Guengerich et al. (1981) reported that irreversible protein and DNA binding of vinyl bromide microsomal metabolites occurred

in vitro. Two suspected alkylating metabolites of vinyl bromide, 2-bromoethylene oxide and 2-bromoacetaldehyde, were studied to determine their roles in irreversible binding. The metabolite, 2-bromoacetaldehyde, was observed to undergo glutathione conjugation. The addition of glutathione to an incubation mixture containing vinyl bromide and liver microsomes from phenobarbital treated rats blocked the binding of metabolites to protein, but not to DNA binding. In a separate assay, glutathione blocked the binding of 2-bromoacetaldehyde to protein; binding of this metabolite to DNA did not occur either in the presence or absence of glutathione. These results support the hypothesis that 2-bromoethylene oxide binds primarily to DNA and 2-bromoacetaldehyde binds primarily to protein.

4.4. EXCRETION

Andersen et al. (1980) reported that the elimination of unmetabolized vinyl bromide will primarily proceed via exhalation. Rapid absorption and excretion of vinyl bromide by the lungs was suggested by Leong and Torkelson (1970) to account for the rapid onset of sedation and recovery of vinyl bromide anesthetized animals.

5. EFFECT

5.1. CARCINOGENICITY

Benya et al. (1982) conducted an inhalation carcinogenicity bioassay of vinyl bromide in rats. Groups of 120 male and 120 female Sprague-Dawley rats were exposed to 0, 10, 50, 250 or 1250 ppm vinyl bromide 6 hours/day, 5 days/week until 25% of the animals in each dose/sex group died or were moribund. This was equivalent to 104 weeks for the three lower levels and 78 weeks for the highest level. Control rats (144 males and 144 females) were exposed to clean, filtered air for 104 weeks. An unexposed group of 10 male and 10 female rats was used to obtain baseline hematologic, urinary, clinical chemistry and bromide levels. Body weights were recorded weekly and blood and urine analyses were conducted at 6-, 12- and 18-month intervals. All animals found dead and those surviving treatment underwent complete histopathological analysis.

Rats exposed to 1250 ppm had elevated liver and kidney weights, microcytic anemia, reduced hemoglobin concentrations, reduced red blood cell counts (RBC) and reduced hematocrit values. Dose-related decreases in survival and body weights were observed. The authors ascribed these changes to the tumorigenic effects, as well as to toxicity and stress.

Statistically significant increased incidences of liver angiosarcomas were observed in both sexes of rats at all exposure levels (see Appendices B and C). These tumors occurred in 84/240 at 1250 ppm, 122/240 at 250 ppm, 86/240 at 50 ppm, 17/240 at 10 ppm and 1/288 at 0 ppm. Statistically significant increases in squamous cell carcinomas of the Zymbal gland were found in male and female rats exposed to 1250 ppm and male rats exposed to 250 ppm, but not in any other sex/dose groups. An increased incidence of hepatocellular carcinomas was observed in female rats exposed to 250 ppm but

not in any other sex/dose group. A clear dose-response relationship regarding angiosarcoma was observed, with the exception of the highest dosage level. Early termination of the study in the 1250 ppm group due to mortality is a likely explanation for this exception.

Van Duuren (1977) reported the absence of tumors in mice upon cutaneous or subcutaneous administration of vinyl bromide for 420 days. A group of 30 female ICR/Ha Swiss mice received skin applications of 15 mg vinyl bromide 3 times/week for 420 days. No skin or other tumors developed within 420 days, but complete pathological evaluations were not performed. A group of 30 female ICR/Ha Swiss mice received weekly subcutaneous injections of 25 mg vinyl bromide for 42 weeks and were observed for an additional 84 days. No local tumors developed, but complete histopathological evaluations were not performed.

5.2. MUTAGENICITY

Mutagenicity of vinyl bromide toward Salmonella typhimurium in vitro has been demonstrated by Bartsch et al. (1976, 1979, 1980) and Lijinsky and Andrews (1980). Table 5-1 summarizes mutagenicity studies with vinyl bromide. S. typhimurium strain TA100 underwent reverse mutation in the presence of vinyl bromide and mouse liver S-9 (with and without NADPH) or human liver S-15. Strain TA1525 underwent reverse mutation in the presence of vinyl bromide and mouse S-9 with NADPH. Unpublished reports by Simmons (1976) and Sparrow (1976) indicate that vinyl bromide induced mutations in S. typhimurium and Tradescantia, respectively.

Vinyl bromide metabolism leads to reactive intermediates (2-bromoethylene oxide and 2-bromoacetaldehyde), which are likely to be involved in the observed genotoxic effects of vinyl bromide (Bolt et al., 1981, 1982; Guengerich, 1981; Guengerich et al., 1981).

TABLE 5-1
Mutagenicity Testing of Vinyl Bromide

Assay	Indicator Organism	Concentration	Application	Mammalian Activation	Response	Comment	Reference
Reverse mutation	<u>S. typhimurium</u> TA100	2.3 μ m/plate	vapor	⁺ mouse liver S-9	⁺	enhanced with S-9	Bartsch et al., 1979
Reverse mutation	<u>S. typhimurium</u> TA100	2.3 μ m/plate	vapor	⁺ human liver S-15	⁺	NC	Bartsch et al., 1979
Reverse mutation	<u>S. typhimurium</u> TA1535	0.2% for 16 hours	vapor	⁺ mouse liver S-9	⁺	NC	Bartsch et al., 1979
Reverse mutation	<u>S. typhimurium</u> TA100	50,000-100,000 ppm	vapor	⁺ rat liver S-9	⁺	NC	Lijinsky and Andrews, 1980
Reverse mutation	<u>S. typhimurium</u>	NR	NR	NR	⁺	unpublished	Simmons, 1976
NR	<u>Tradescantia</u>	NR	vapor	-	⁺	unpublished	Sparrow, 1976

NC = No comment; NR = Not reported

⁺, positive; -, negative; ⁺, positive with and negative without S9 activation system

5.3. TERATOGENICITY

Pertinent data regarding the teratogenicity of vinyl bromide were not located in the available literature.

5.4. OTHER REPRODUCTIVE EFFECTS

Pertinent data regarding other reproductive effects of vinyl bromide were not located in the available literature.

5.5. SUBCHRONIC AND CHRONIC TOXICITY

Leong and Torkelson (1970) reported the results of a subchronic inhalation toxicity experiment conducted with rats, rabbits and monkeys. Groups containing equal numbers of each sex consisting of 60 Charles River rats, 6 New Zealand white rabbits and 6 cynomolgus monkeys were exposed to 0, 250 or 500 ppm vinyl bromide vapors 6 hours/day, 5 days/week for 6 months. Body weights, food consumption and behavioral observations were recorded. Hematological measurements taken prior to exposure (control) and after 2, 10 and 24 weeks of exposure, showed no abnormal treatment-related deviation. A correlation between blood bromine concentration and vinyl bromide exposure concentration was found in all species after 26 weeks of exposure.

Histopathological examination indicated no significant treatment-related effects on gross pathology, organ-to-body weight ratios, or histological alteration in tissues of any species. No evidence of bromism was observed in any species at any exposure level.

Benya et al. (1982) observed increased liver and kidney weights and alterations in hematological parameters (i.e., reduced RBC, hemoglobin and hematocrit) in rats exposed to 1250 ppm vinyl bromide vapors for 78 weeks but not in those exposed to 250, 50 or 10 ppm for 104 weeks. Mortality and reduced body weight gain were observed to be dose-related. The authors ascribed these changes not only to toxicity and stress, but also to the tumorigenic effects (see Section 5.1.).

5.6. OTHER RELEVANT INFORMATION

Leong and Torkelson (1970) reported an oral LD_{50} for vinyl bromide of 500 mg/kg in rats fed a 50% solution in corn oil. A 10% vinyl bromide atmospheric concentration was lethal to rats within 15 minutes, but if removed before death, all exposed animals survived. A 5% vinyl bromide atmosphere was lethal to rats after 7 hours of exposure. Exposure of groups of five male Wistar rats to 10,000 ppm of vinyl bromide 7 hours/day, 5 days/week for 3 days or 1, 2 or 4 weeks resulted in reduced body weights and sluggishness, but no gross or microscopic pathologic changes in tissues.

A rise in levels of serum alanine- α -ketoglutarate transaminase is a reflection of hepatotoxicity. Such evidence of acute hepatotoxicity following a 4-hour exposure to vinyl bromide has been reported in rats pretreated with polychlorinated biphenyl (Conolly et al., 1978; Conolly and Jaeger, 1977).

6. AQUATIC TOXICITY

The only data available on the toxicity of vinyl bromide in the aquatic environment are those on its effects on marine phytoplankton. Pertinent data regarding acute or chronic toxicity in fish, residues in aquatic organisms, or other relevant information were not located in the available literature.

The effects of vinyl bromide on mixed marine phytoplankton at concentrations of 0.5, 1.0 and 2.0 mg/l were determined by uptake of ^{14}C as a measure of photosynthesis (Erickson and Hawkins, 1980). Organisms in the mixed cultures included Glenodinium halli, Skeletonema costatum, Thalassiosira pseudomona and Isochrysis galbana. At the exposure levels tested (0.5, 1.0 and 2.0 mg/l), ^{14}C uptake was 113, 103 and 97%, respectively, of untreated control levels after 24 hours. A 24-hour toxic concentration of vinyl bromide must, therefore, be >2.0 mg/l for a mixed culture of these marine phytoplankton (Erickson and Hawkins, 1980).

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

Because of its demonstrated animal carcinogenicity, the American Conference of Governmental Industrial Hygienists (ACGIH, 1980) has given vinyl bromide an A2 (suspected carcinogen) classification. ACGIH recommends a TLV of 5 ppm for an 8-hour TWA and a 20 ppm STEL for 15-minute exposures. The National Institute for Occupational Safety and Health (NIOSH, 1978) recommends a 1 ppm limit for an 8-hour TWA and a 5 ppm STEL.

7.2. AQUATIC

Guidelines and standards for the protection of aquatic organisms from the toxic effects of vinyl bromide were not located in the available literature.

8. RISK ASSESSMENT

In the inhalation study by Benya et al. (1982), exposure of rats to vinyl bromide resulted in dose-related, increased incidences of angiosarcoma of the liver in both males and females, increased incidences of squamous cell carcinoma of the Zymbal gland in both males and females at high exposure levels, and an increased incidence of hepatocellular carcinoma in females at the second highest (but not the highest) exposure level. This evidence, as well as positive results in several mutagenicity assays (see Section 5.2.), and the structural similarity between vinyl bromide and a known human carcinogen, vinyl chloride, indicates that vinyl bromide should be regarded as a carcinogen.

The carcinogenicity bioassay of Benya et al. (1982) is the only study that provides sufficient data from which an estimate of a carcinogenic potency factor (q_1^*) can be derived for humans. Data for the derivation of the (q_1^*) are shown in Appendices B and C. The exposure levels 0, 10, 50, 250 and 1250 ppm are equivalent to 0, 43.7, 218.6, 1093 and 5465 mg/m³, respectively. The highest exposure level, 1250 ppm, caused early mortality; hence, the duration of exposure was shorter for this level than for the other levels. This exposure level is therefore omitted from this risk assessment. The transformed doses of 0, 2.7, 10.4 and 52.0 mg/kg/day for males and 0, 2.4, 12.0 and 60.0 mg/kg/day for females are obtained by expanding the 0, 10, 50 and 250 ppm exposure levels from 6 to 24 hours and from 5 to 7 days, and by multiplying by the inhalation rate of the rat (0.32 m³/day for 600 g males and 0.24 m³/day for 390 g females) and by 0.5 (the assumed absorption factor), and then dividing the quantity by the average body weight of the rats.

Based on the data of Benya et al. (1982) wherein the incidence of liver angiosarcomas in male rats were 0/144 (controls), 7/120, 36/120 and 61/120 in order of increasing dose, and using the linearized multistage model developed by Kenneth Crump (1980) and adopted by the U.S. EPA, a q_1^* of $1.046 \times 10^{-1} \text{ (mg/kg/day)}^{-1}$ can be derived for humans. The corresponding dose associated with an increased lifetime risk of 10^{-5} is $9.56 \times 10^{-4} \text{ mg/kg/day}$ or $6.69 \times 10^{-3} \text{ mg/day}$ for a 70 kg man. Similarly, based on the incidence of liver angiosarcomas in female rats (1/144 in controls and 10/120, 50/120 and 61/120 in treated groups in order of increasing dose) in the same study, a human q_1^* of $1.127 \times 10^{-1} \text{ (mg/kg/day)}^{-1}$ can be derived, which corresponds at the 10^{-5} risk level to a dose of $8.87 \times 10^{-4} \text{ mg/kg/day}$, or $6.21 \times 10^{-3} \text{ mg/day}$ for a 70 kg man. The data for the female rats result in a slightly more conservative dose at the 10^{-5} risk level than do the data for male rats, but the values are similar.

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APPENDIX A
LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of:

CA SEARCH (Files 308, 309, 310, 311, 320)
TOXLINE
MEDLINE
RTECS
SCI SEARCH
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE
EPCASR
Chemical Industry Notes

Most of these searches were conducted in February, 1983; a few were conducted March-May, 1983. In addition, hand searches were made of Chemical Abstracts (Collective Indices 7 and 8th), and the following secondary sources were reviewed:

ACGIH (American Conference of Governmental Industrial Hygienists). 1980. TLVs: Documentation of the Threshold Limit Values, 4th ed. (Includes Supplemental Documentation, 1981). Cincinnati, OH. 486 p.

ACGIH (American Conference of Governmental Industrial Hygienists). 1982. Documentation of the Threshold Limit Values for Chemical Substances in Work Air. Cincinnati, OH. 94 p.

Bruin, P., G.J. Bergen and J.J. Desta, Ed. 1980. Handling Chemicals Safely, 2nd ed. Dutch Assoc. of Safety Experts, Dutch Chemical Industry Assoc., and Dutch Safety Institute, The Netherlands. 1013 p.

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APPENDIX B

Cancer Data Sheet for Derivation of q_1^*

Compound: Vinyl bromide

Reference: Benya et al., 1982

Species, Strain, Sex: Rat, Sprague-Dawley, male

Body Weight: 0.60 kg (measured)

Length of Exposure (t_e) = 730 days

Length of Experiment (L_e) = 730 days

Lifespan of Animal (L) = 730 days

Tumor Site and Type: liver/angiosarcoma

Route, Vehicle: inhalation, vapor, no vehicle

Experimental Doses or Exposures (6 hours/day, 5 days/week x 730 days)	Transformed Dose (mg/kg/day)	Incidence No. Responding/ No. Tested (or Examined)
0	0	0/144
43.7 mg/m ³	2.1	7/120
218.6 mg/m ³	10.4	36/120
1093.1 mg/m ³	52.0	61/120

Human $q_1^* = 1.0 \times 10^{-1} \text{ (mg/kg/day)}^{-1}$

10^{-5} risk level = $9.56 \times 10^{-5} \text{ mg/kg/day} = 6.69 \times 10^{-5} \text{ mg/day}$ for 70 kg man

APPENDIX C

Cancer Data Sheet for Derivation of q_1^*

Compound: Vinyl bromide

Reference: Benya et al., 1982

Species, Strain, Sex: Rat, Sprague-Dawley, female

Body Weight: 0.39 kg (measured)

Length of Exposure (t_e) = 730 days

Length of Experiment (L_e) = 730 days

Lifespan of Animal (L) = 730 days

Tumor Site and Type: liver/angiosarcoma

Route, Vehicle: inhalation, vapor, no vehicle

Experimental Doses or Exposures (6 hours/day, 5 days/week x 730 days)	Transformed Dose (mg/kg/day)	Incidence No. Responding/No. Tested (or Examined)
0	0	0/144
43.7 mg/m ³	2.4	10/120
218.6 mg/m ³	12.0	50/120
1093.1 mg/m ³	60.0	61/120

Human $q_1^* = 1.127 \times 10^{-1} \text{ (mg/kg/day)}^{-1}$

10^{-5} risk level = $8.87 \times 10^{-5} \text{ mg/kg/day} = 6.21 \times 10^{-5} \text{ mg/day}$ for 70 kg man